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Advanced Wideband System (AWS)

Analysis of Alternatives for Wideband Military Satellite Communications in the 2008+ Timeframe

CNS Workshop
Cleveland, OH
1-3 May 2001

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Outline

- Military Satellite Communications (MILSATCOM) Architecture
- Military Use of Commercial Satellite Bus Designs
- The Wideband Gapfiller System (WGS)
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- Possible AWS Technologies

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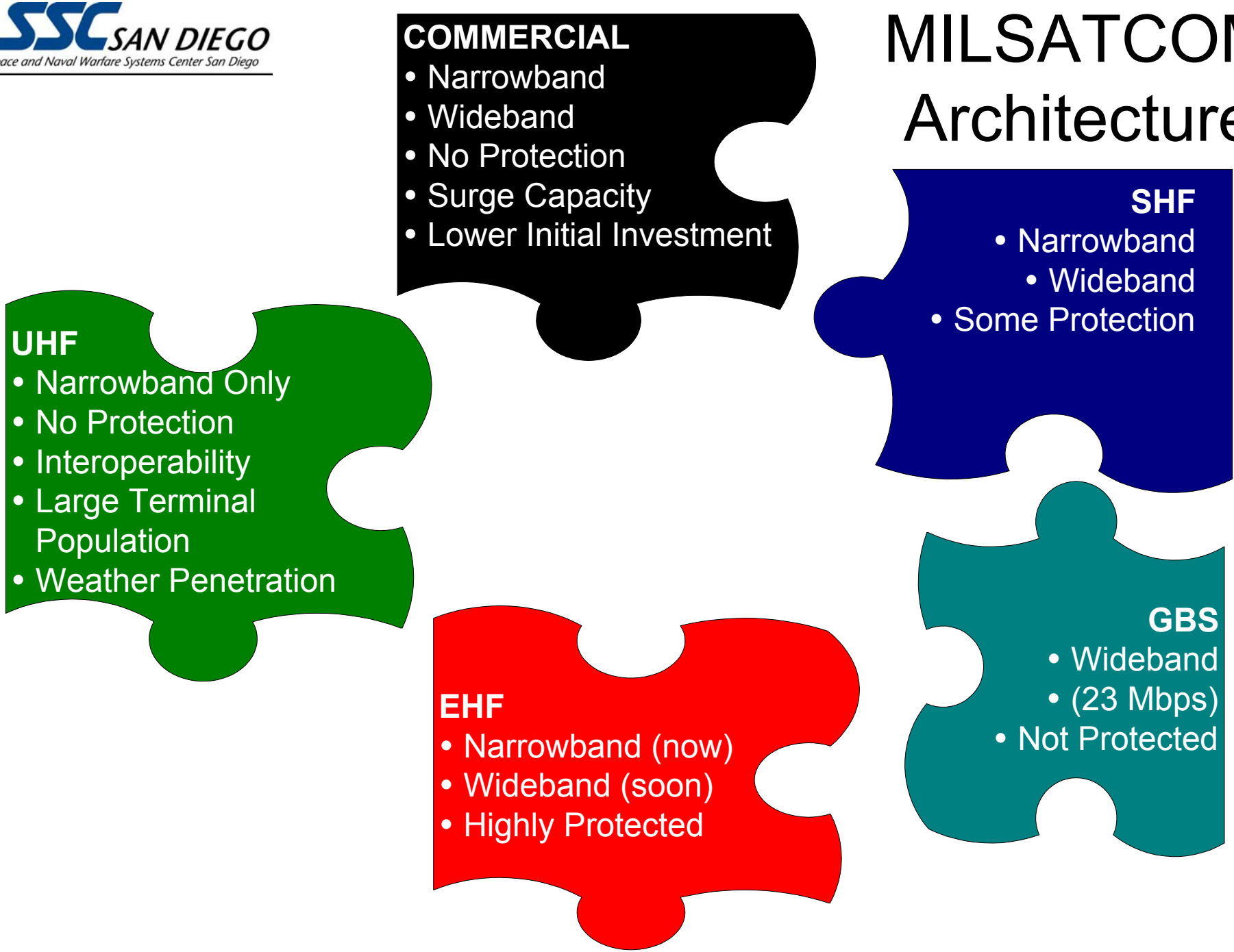
MILSATCOM Architecture



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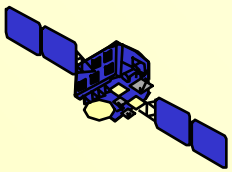
Today's MILSATCOM

Wideband Service	Protected Service	Narrowband Service	Augment

DSCS



- Long-Haul
- Some Anti-Jam
- Medium and High Data Rates
- Evolving to Tactical Focus

SHF

System starts degrading 2003-2005

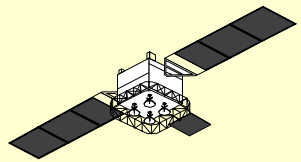
MILSTAR

- Tactical Anti-Jam
- Low and Medium Data Rates

EHF

System starts degrading 2003-2007

UHF Follow-On

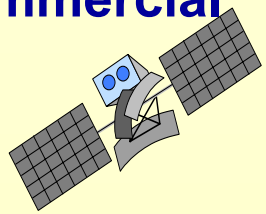


- Warfighter Nets
- Unprotected
- Low Data Rates
- GBS

UHF

System starts degrading 2003-2007

Commercial



- Mostly Wideband
- No Protection
- Landing Rights Issues
- Compete for Access

Many Emerging Systems

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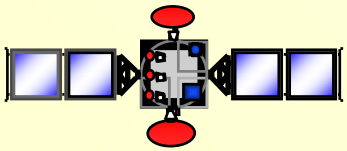
Recommended MILSATCOM

High Capacity Service	Protected Service	Mobile Service	Augment

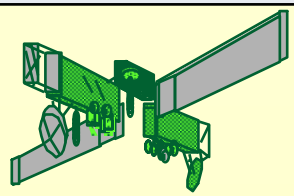


Advanced Wideband System

- Tactical Focus
- High Capacity, 2 way and Broadcast, Ka and X-band
- **Commercial-Like**
- Increased Capability
- Processed Ka
- Common Waveform for Ka and EHF

SHF

First Launch 2003/2006

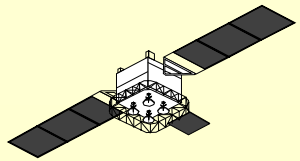


Advanced EHF

- Higher Data Rates
- 6-10x Increase in Capability
- MILSTAR Waveform

EHF

First Launch 2006



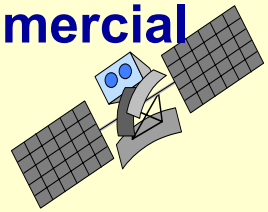
High Mobility

- Warfighter Nets
- Handheld PCS e.g. wireless

UHF

First Launch 2007/2010

Commercial



Examples include:

- Iridium, Globalstar
- INTELSAT
- INMARSAT

Leverage Emerging Systems

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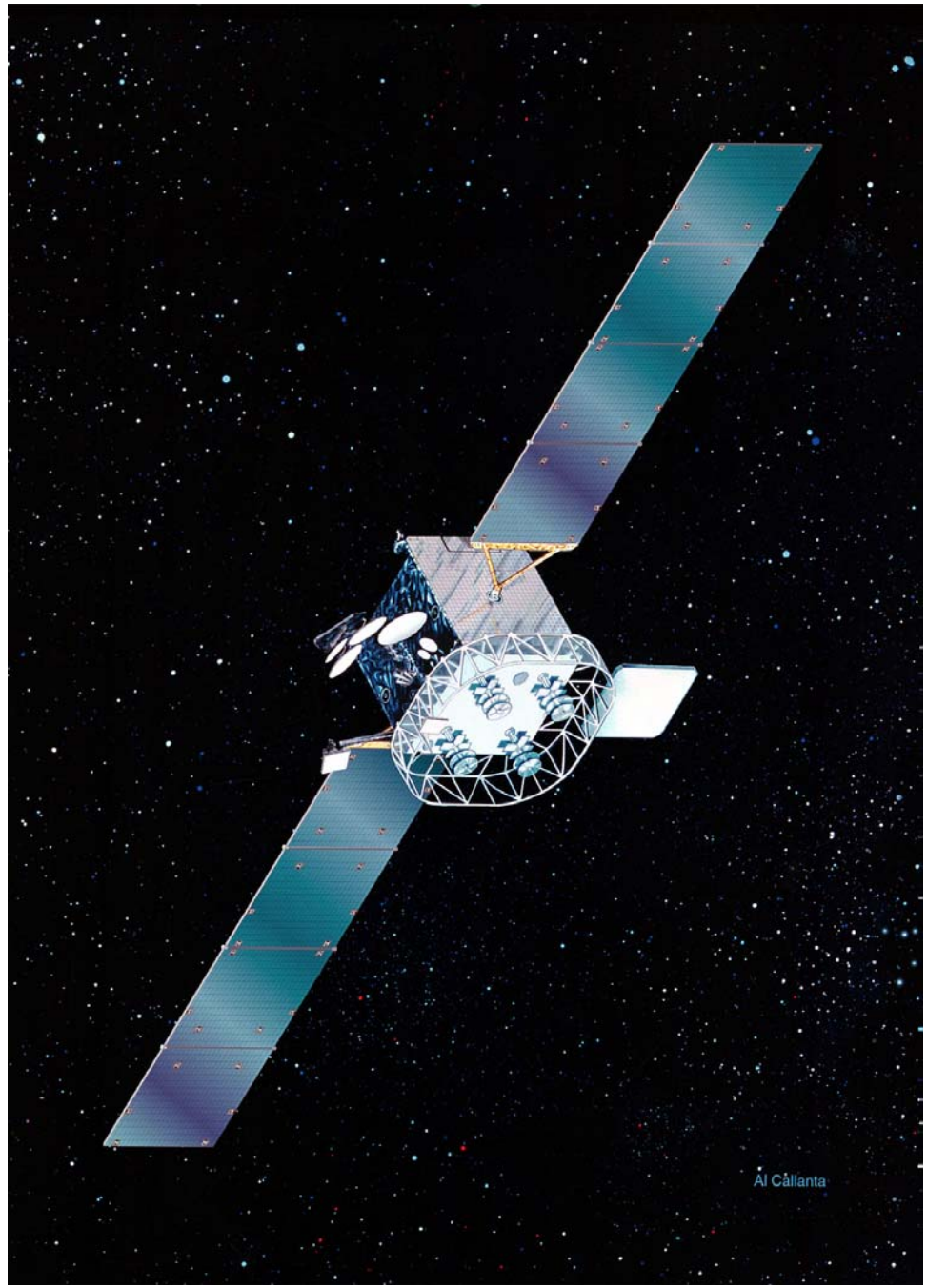
UHF Follow-On (UFO)

- Bus
  - Hughes 601
    - Now Boeing 601
- Missions
  - UHF (F1 - F11)
  - EHF (F4 - F11)
  - GBS (F8 - F10)
    - 30/20 GHz



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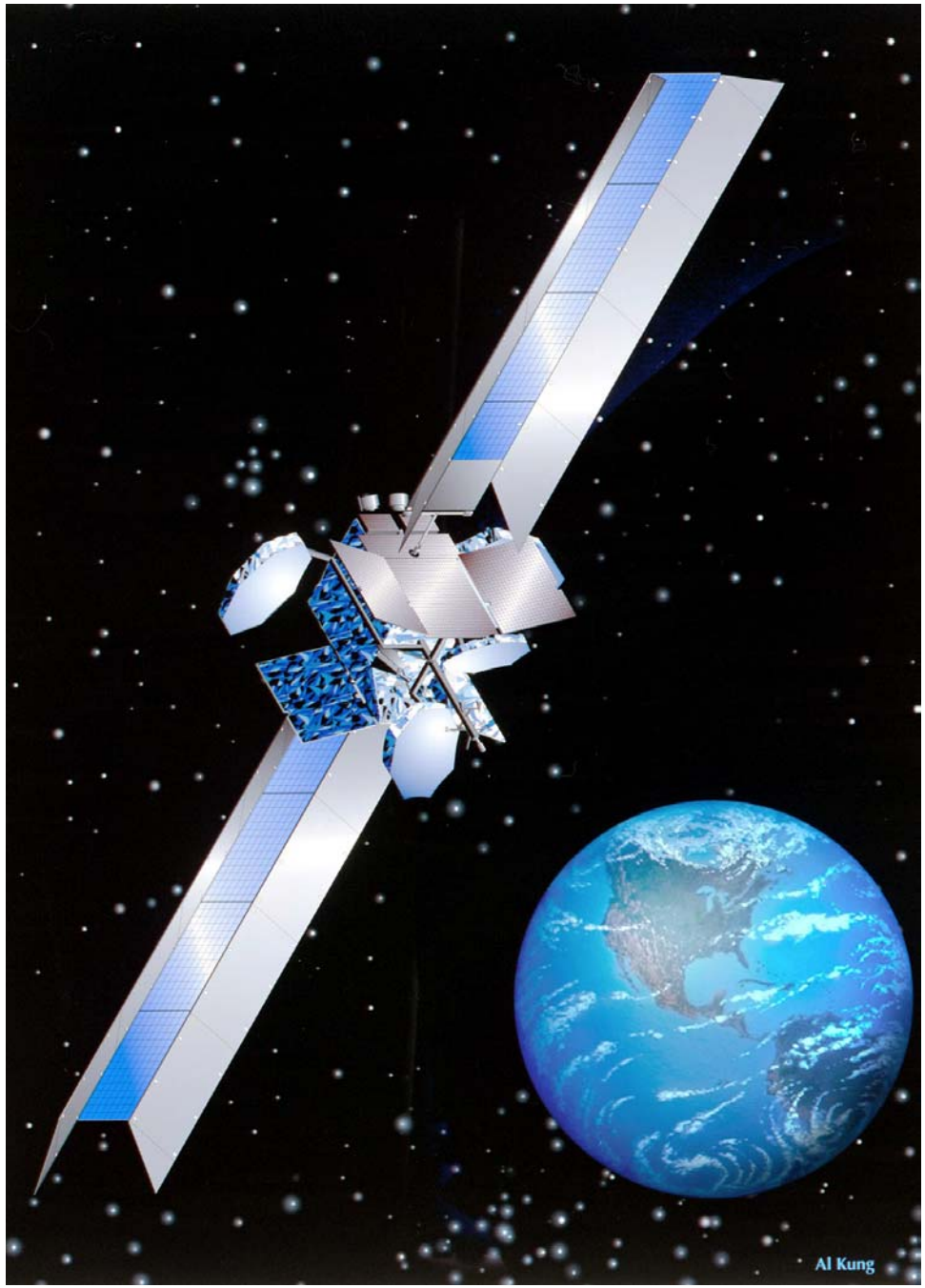
Wideband Gapfiller System (WGS)

- Bus
  - Hughes 702
    - Now Boeing 702
- Missions
  - Tactical Wideband
    - X-band 2-way
    - K/Ka-band 2-way
  - GBS
    - X & K-bands



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Spacecraft Compared

Satellite	Electrical Power	Comms Capacity	Cost per Satellite	Life-Time	Terminal Population
• UFO	2.5 - 3.8 kW*	LDR	$170M	10 yrs	12,000
• MUOS	t.b.d.	t.b.d.	$1,000M	t.b.d.	17,000
• MILSTAR I	8 kW	0.5 Mbps	$800M	10 yrs	2,000
• MILSTAR II	8 kW	40 Mbps	$800M	10 yrs	2,000
• AEHF	t.b.d.	375 Mbps	$1,000M	t.b.d.	>2,000
• DSCS III	1.3 kW	100 Mbps	$200M	10 yrs	1,000
• DSCS SLEP	1.5 kW	200 Mbps	$200M	10 yrs	1,000
• WGS	18 kW	3,600 Mbps	$184M	15 yrs	>1,000

UFO Flights	*Power	Payloads
F1 - F3	2.5 kW	UHF/SHF
F4 - F7	2.8 kW	UHF/SHF/EHF
F8 - F10	3.8 kW	UHF/EHF/GBS
F11	2.8 kW	UHF/EHF

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Wideband Gapfiller System (WGS)

- The 1996 Senior Warfighters' Forum (SWarF) provided guidance to the DoD MILSATCOM Community to develop an X and Ka wideband Gapfiller capability, based on best commercial practices, to provide needed bandwidth to the warfighter within budget constraints.
- Based on the SWarF's guidance and concept development, the following parameters are assumed:
- Combined X and Ka-band payload to satisfy wideband requirements
- Transponded X-band service
- GBS service provided in a backwards compatible format
- Two-way Ka-band service which may be transponded or processed
- Satellite cross-banding between the X and Ka services

Ref.: MILSATCOM Joint Terminal Engineering Office (JTEO),
"Gapfiller Terminals Industry White Paper,"
July 2000

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WGS Spacecraft Antennas

Band	Beam Type	No.	Cross-Pol?	Beamwidth (Degrees) (nadir coverage)
Ka	NCA	3	N	1.79 (705,000 km^2)
	High Power NCA	3	N	1.79 (705,000 km^2)
	ENCA	2	Y (1)	4.77 (6,500,000 km^2)
	High Power ENCA	2	Y	1.79 (705,000 km^2)
X	MCA	4	N	2.42-8.82
	DCA	4	N	2.42
	ECA	1	N	17.60 (whole earth)

On Each Satellite

- 10 Ka-band beams
  - Ten gimbaled dishes (GDA)
- 8 X-band beams
  - Two phased arrays (Tx & Rx)
- 1 X-band earth coverage
  - Horn

Frequency Bands (GHz)

7.25-7.75 Space-to-Earth
7.90-8.40 Earth-to-Space
20.2-21.2 Space-to-Earth
30.0-31.0 Earth-to-Space

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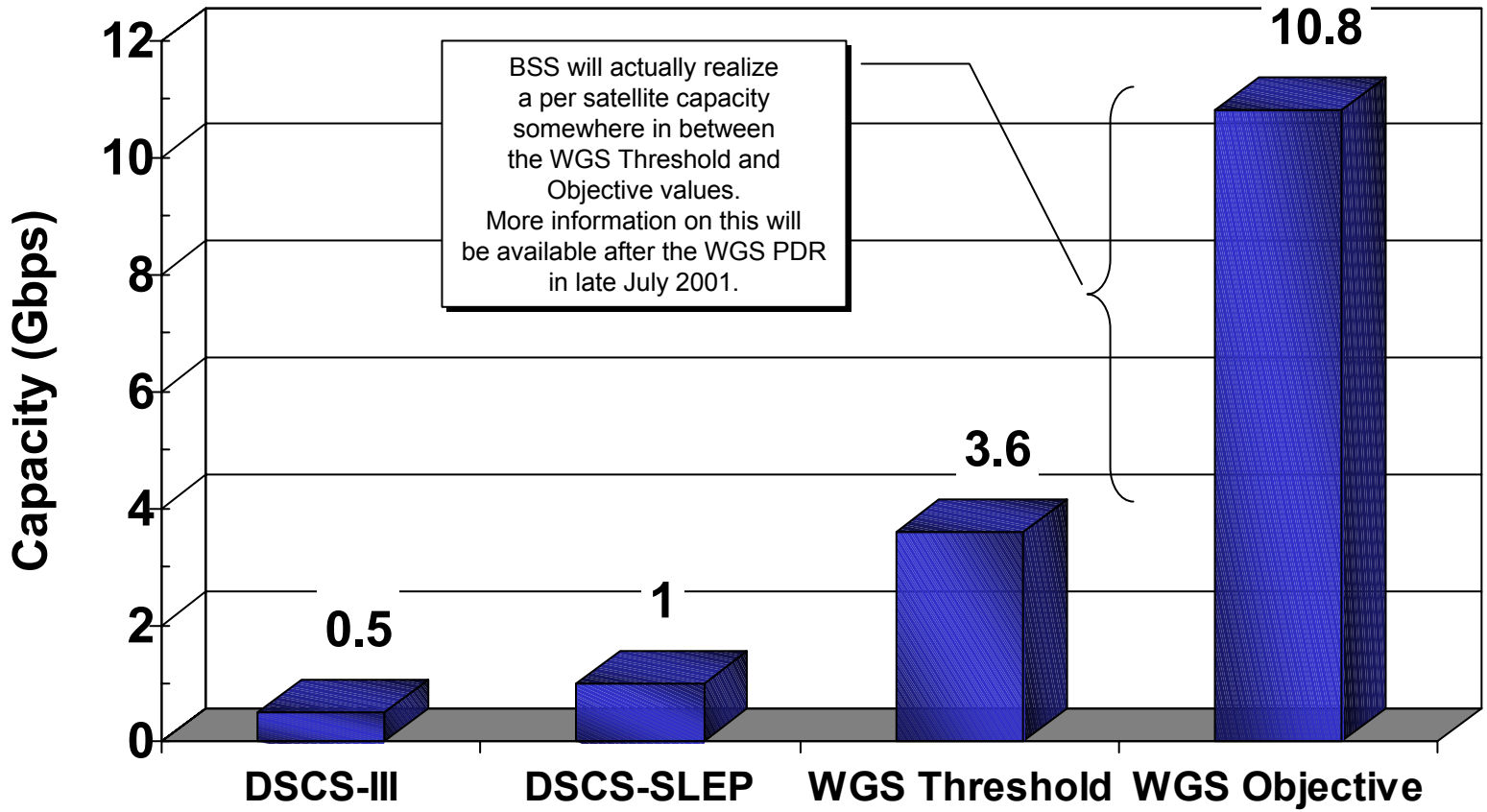
Constellation Capacities

Notes:

DSCS-III:	5 satellites @ 100 Mbps	
DSCS-SLEP:	5 satellites @ 200 Mbps	
WGS Thresh.:	3 satellites @ 1,200 Mbps	WGS ORD
WGS Object.:	3 satellites @ 3,600 Mbps	



TOTAL CONSTELLATION CAPACITY

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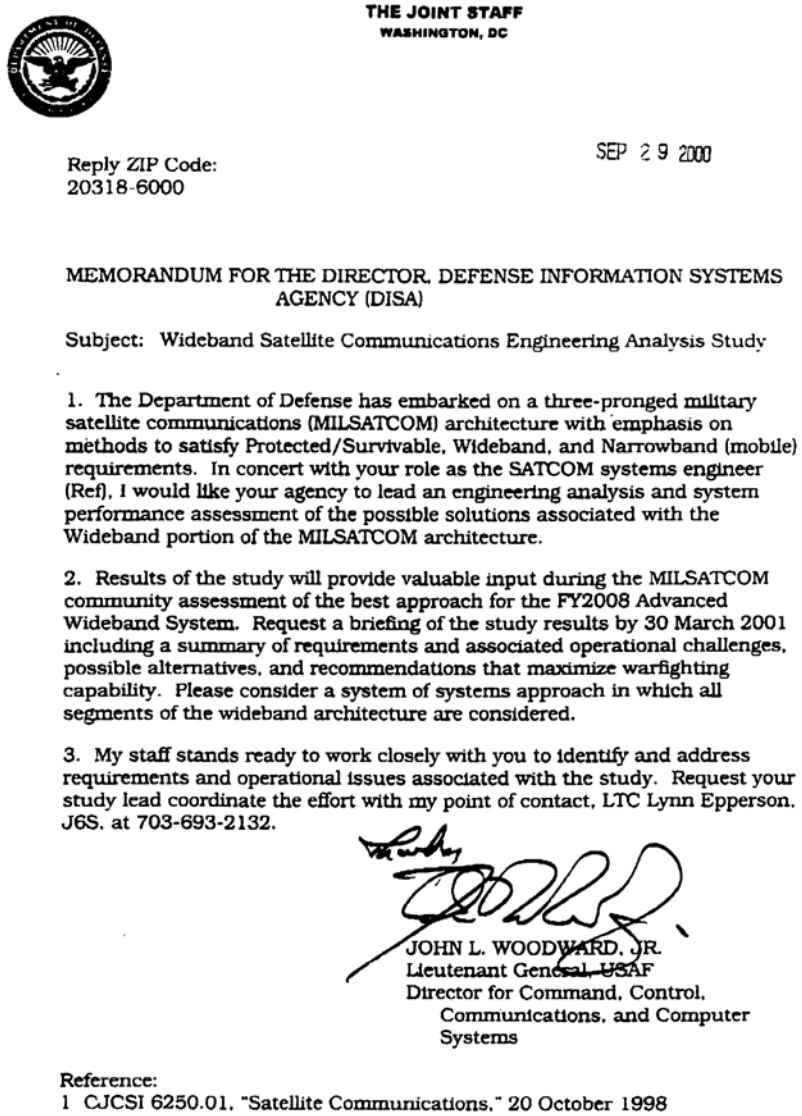
AWS AoA

- **JCS tasking to DISA on 29-Sep-2000**
  - **"lead an engineering analysis and system performance assessment of possible solutions… will provide... input into community assessment of the best approach for the FY 2008 Advanced Wideband System."**



THE JOINT STAFF
WASHINGTON, DC

Reply ZIP Code:
20318-6000

SEP 29 2000

MEMORANDUM FOR THE DIRECTOR, DEFENSE INFORMATION SYSTEMS AGENCY (DISA)

Subject: Wideband Satellite Communications Engineering Analysis Study

1. The Department of Defense has embarked on a three-pronged military satellite communications (MILSATCOM) architecture with emphasis on methods to satisfy Protected/Survivable, Wideband, and Narrowband (mobile) requirements. In concert with your role as the SATCOM systems engineer (Ref), I would like your agency to lead an engineering analysis and system performance assessment of the possible solutions associated with the Wideband portion of the MILSATCOM architecture.

2. Results of the study will provide valuable input during the MILSATCOM community assessment of the best approach for the FY2008 Advanced Wideband System. Request a briefing of the study results by 30 March 2001 including a summary of requirements and associated operational challenges, possible alternatives, and recommendations that maximize warfighting capability. Please consider a system of systems approach in which all segments of the wideband architecture are considered.

3. My staff stands ready to work closely with you to identify and address requirements and operational issues associated with the study. Request your study lead coordinate the effort with my point of contact, LTC Lynn Epperson, J6S, at 703-693-2132.

JOHN L. WOODWARD, JR.
Lieutenant General, USAF
Director for Command, Control, Communications, and Computer Systems

Reference:
1 CJCSI 6250.01, "Satellite Communications," 20 October 1998

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Evaluation Metrics

Criteria	G	Y	R
Capacity (2015 CMTW) (% Allocated Mbps Satisfied)	100-80%	80-60%	<60%
Coverage with Capacity X-Band (% EFOV Covered) Ka-Band(% Extended Theater Covered)	**100-80%** **100-80%**	**80- 60%** **80- 60%**	**< 60%** **< 60%**
Assured Access Dynamic connectivity -Average time Information assurance - Outage/month Reliance on Teleport/gateways	**Seconds** **10s min.** **Low**	**Minutes** **100s min.** **Medium**	**10s of min.** **1000s min.** **High**
Terminal Size / Link Rates	**Mostly Smaller/High**	**Legacy & Smaller/ Medium**	**Legacy/ Low**
Control Impacts **Compared to present system (WGS)**	**Low**	**Medium**	**High**
Transition Impacts (**Effects from Legacy)**	**Low**	**Medium**	**High**
Cost Impact **(Reflects complexity)**	**Low**	**Medium**	**High**

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"Current Score"

	WGS Plus	Evolutionary	Hybrid	Revolutionary	Commercial
Capacity	Y	Y	G	G	Y
Coverage with Capacity	R	Y	G	G	R
Assured Access					
Dynamic Connectivity	Y	Y	G	G	Y
Information Assurance	R	R	Y	G	R
Reliance on gateways	G	G	Y	G	R
Terminal size & link rates	R	R	Y	G	Y
Network Control Complexity	G	G	Y	Y	Y
Ease of transition	G	G	Y	Y	R
Cost POM Impact	G	G	G	Y	Y

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Emerging Commercial SATCOM Services

- Data broadcasting (data casting, IP multicasting) and content distribution enabled by low cost DVB-based receiver cards;
- Low to medium data rate personal communications provided by regional GEO and global LEO/MEO satellite systems;
- Satellite Internet access from low-cost satellite terminals that are smaller than one meter;
- Digital Audio Radio (DARS) or Digital Audio Broadcasting (DABS)

Satellite Technologies

- Spot beams & spatial frequency re-use
- Active phased array antennas
- High power satellite platforms (15-35 kW)
- On board switching
  - Baseband processing and signal regeneration
  - Microwave switch matrix
- Space qualified μ-processors, ICs, EPFGAs, EPROMs
- SSPA & TWTA improvements
- Electric ion propulsion systems
- Optical technologies for onboard processing and intersatellite links (ISL)

Earth Terminal Technologies

- IP as common network technology for interoperability
- Higher order modulation, increased spectral efficiency
- Turbo Code chip sets and modem implementations
- Digital Video Broadcast (DVB) standards including the DVB Return Channel Specification (DVB-RCS)
- TCP performance enhancing proxies
- Modular earth stations
- Software for bandwidth management (DAMA), multiple access control, multiplexing and routing of data, monitoring and control
- Slotted array, active array, lens, and steerable dish antennas for tracking NGSO satellites and for mobile earth stations

Summary

- MILSATCOM requirements cannot be completely satisfied by Commercial SATCOM services.
  - Coverage issues
  - Information assurance issues
  - Cost?
- Commercial SATCOM technologies are increasingly used in MILSATCOM *where it makes sense*
  - Satellite busses
  - DVB
    - GBS
- DoD seeks maximum interaction with industry to refine AWS AoA